HUNTING PATTERNS AND THE DISTRIBUTION OF THE BEVERLY, BATHURST AND KAMINURIAK CARIBOU HERDS BASED ON THE RETURN OF TAGS BY HUNTERS

Northwest Territories Resources, Wildlife & Economic Development

103-05784/

HUNTING PATTERNS AND THE DISTRIBUTION OF THE BEVERLY, BATHURST AND KAMINURIAK CARIBOU HERDS BASED ON THE RETURN OF TAGS BY HUNTERS

D. C. HEARD

N.W.T. WILDLIFE SERVICE

1984

File Report No. 37

Contents of this paper may be used only with the permission of the N.W.T. Wildlife Service.

ABSTRACT

More than 10,000 barren-ground caribou (Rangifer tarandus groenlandicus) in the Beverly, Bathurst and Kaminuriak caribou herds of the Northwest Territories have been marked with ear tags, neck collars or both since 1959. The objective of this marking program was to learn more about herd movements and seasonal distribution, to document interchange of caribou among herds, and to collect information on the numbers, distribution, sex and age of caribou shot by hunters. Data from Kaminuriak herd tags returned before 1966 and Beverly and Bathurst tags returned before July 1970 have been published. This paper analyzes the subsequent tagging and return data and compares the results with those already published. Since the 1966 and 1970 analyses, over 1,300 caribou have been tagged and 180 tags (25% of all returns) have been recovered. Tag return rates were 7.2%, 5.0% and 6.4% for the Beverly, Bathurst and Kaminuriak herds respectively. The recent tag recoveries document the same hunting trends as interpreted from the earlier returns. More males than expected were shot (based on the number tagged) and more caribou were shot in winter than summer. Tag return locations indicated that the ranges of all three herds were, with one exception, distinct and stable over time. Part of the winter range of the Kaminuriak and Beverly herds overlapped throughout the tag return period. There was no evidence to suggest that there was any major shift of caribou from one herd to another.

TABLE OF CONTENTS

ABSTRACT iii

LIST OF FIGURES vii

LIST OF TABLES viii

INTRODUCTION 1

METHODS 4

RESULTS AND DISCUSSION 5
Tagging 5
Tag Recoveries 5
Natural Mortality, Hunter Kill and Population Estimates 12
Distribution of Tagged Caribou 14

ACKNOWLEDGEMENTS 27

PERSONAL COMMUNICATIONS 28

LITERATURE CITED 29

APPENDIX A. Number and description of ear tags applied between 1960 and 1977 to Beverly caribou at Box Crossing on the Thelon River and at Mary Frances Lake 31

APPENDIX B. Number and description of ear tags applied between 1960 and 1979 to Bathurst caribou at Contwoyto Lake 33

APPENDIX C. Numbering series for caribou tagged between July 28 and August 1, 1979 at the Contwoyto Lake site 34

APPENDIX D. Number and description of ear tags applied between 1959 and 1970 to Kaminuriak caribou 35

APPENDIX E. Numbering series for Kaminuriak caribou tagged between 1959 and 1970 37

APPENDIX F. Age, sex and season shot for tagged Beverly caribou returned by hunters before and after 1970 39

APPENDIX G. Age, sex and season shot for tagged Bathurst caribou returned by hunters before and after 1970 40

APPENDIX H. Age, sex and season shot for tagged Kaminuriak caribou returned by hunters before and after 1966 41

APPENDIX I. Comparisons of sex ratio and season shot for caribou recovered from atypical locations with those caribou recovered from within the normal range of the Beverly and Kaminuriak herds 42

APPENDIX J. Methods and calculations of dispersal rates from tag recovery data 44

LIST OF FIGURES

Figure 1. Distribution of caribou ear-tags returned after 1966 from caribou marked at Duck Lake and after 1970 from caribou marked at Contwoyto Lake, Mary Frances Lake and the Thelon River 2

Figure 2. Proportion of all caribou ear-tags returned in each year (July to July) after tagging 13

Figure 3. The number of Beverly and Kaminuriak caribou ear-tags returned my month above and below treeline 15

Figure 4. Distribution of the Bathurst, Beverly and Kaminuriak caribou herds between 1959 and 1981 based on tag return locations and direct observations, and the location of atypical tag recoveries 22

LIST OF TABLES

Table 1.	Age and sex of Beverly caribou tagged at Box Crossing and Mary Frances Lake	6
Table 2.	Age and sex of Bathurst caribou tagged at Contwoyto Lake	7
Table 3.	Age and sex of Kaminuriak caribou tagged in Manitoba	8
Table 4.	Number of tagged Beverly caribou recovered each year from 1960 to 1981	9
Table 5.	Number of tagged Bathurst caribou recovered each year from 1960 to 1981	10
Table 6.	Number of tagged Kaminuriak caribou recovered each year from 1960 to 1981	11
Table 7.	Age, sex and season shot for the 539 Beverly caribou returned by hunters	16
Table 8.	Age, sex and season shot for the 30 tagged Bathurst caribou resighted or returned by hunters	17
Table 9.	Age, sex and season shot for the 161 tagged Kaminuriak caribou returned by hunters	18
Table 10.	Number of adult caribou of both sexes tagged and recovered in winter and summer in all herds	20
Table 11.	Sex, age when tagged, year tagged, and date shot for each caribou recovered from outside of the range where it was tagged	23
Table 12.	Sex, age and season shot of tagged caribou shot outside normal range as defined in Figure 4	25

INTRODUCTION

Banfield (1954) named 16 herds of barren-ground caribou (Rangifer tarandus groenlandicus) on the mainland of the Northwest Territories but suggested that some interchange might occur between them. The desire 1) to test whether or not these were discrete populations, 2) to learn more about herd movements and seasonal distribution, and 3) to collect information on longevity and hunting mortality led to the initiation of a tagging program in 1959.

Miller and Robertson (1967) analyzed the results of tagging at Little Duck Lake, Manitoba (Duck Lake Site) between 1959 and 1965. Parker (1972a) documented the tags returned up to July 1970 from three other sites; Contwoyto Lake (Contwoyto Site), Box Crossing on the Thelon River (Thelon Site), and Mary Frances Lake (Mary France Site) (Fig. 1).

Those reports showed 1) the extent and timing of caribou movements, 2) that not all of the herds recognized by Banfield (1954) were discrete because tags from both Little Duck Lake and Box Crossing were commonly returned from the winter ranges of up to four of Banfield's "herds", 3) that there was only a small area of overlap between the ranges used by caribou tagged at Little Duck Lake and Box Crossing, and 4) that more caribou are shot in winter. Based on both tag returns and aerial survey observations, Thomas (1969) named four herds where Banfield had recognized 12. He named them the Bluenose, Bathurst, Beverly and Kaminuriak after lakes near the areas traditionally used for calving (Calef and Heard 1980). Little Duck Lake was within the Kaminuriak herd's

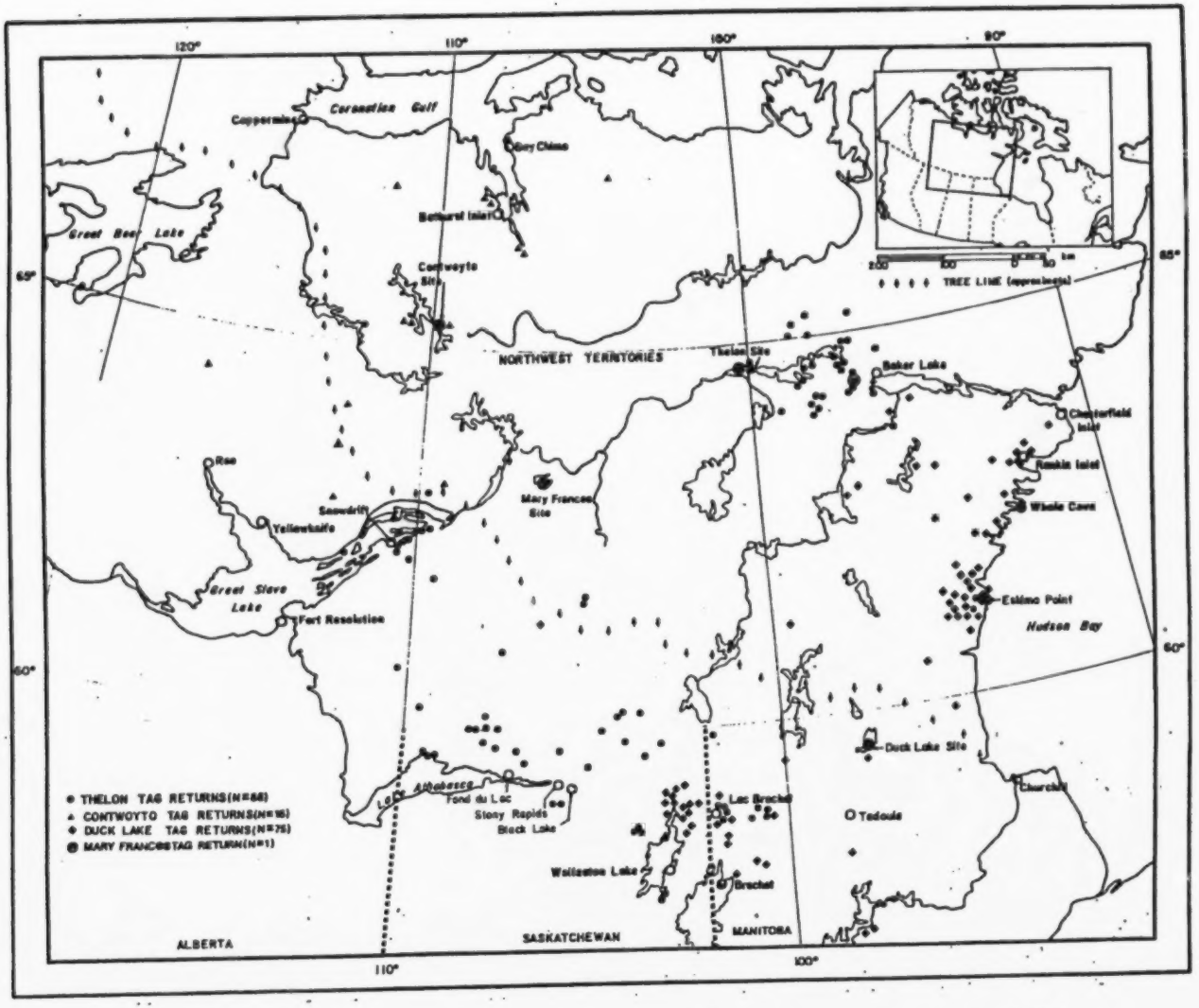

Figure 1. Distribution of caribou ear-tags returned after 1966 from caribou marked at Duck Lake and after 1970 from caribou marked at Contwoyto Lake, Mary Frances Lake and the Thelon River.

range, both Box Crossing and Mary Frances Lake were within the Beverly herd's range and Contwoyto Lake was on the Bathurst herd's range.

Tagging continued on an irregular basis and a substantial number of tags (and/or collars) have been both applied and returned since the summaries by Miller and Robertson (1967) and Parker (1972a). The most recent marking occurred in 1979. This report documents these recent results up to 31 December 1981 and compares them with the earlier papers.

METHODS

Caribou were marked with ear tags, neck collars or both. Except for 75 caribou that were driven into tangle nets in April 1970 (Miller et al. 1975), all caribou were captured during summer as they swam lakes and rivers that were in the path of their migration. Swimming caribou were approached by tagging crews in boats driven by outboard motors and a sheperd-like crook was used to bring the caribou along side the boat (Miller and Robertson 1967). The number and description of the ear tags are described in Appendices A to E.

RESULTS AND DISCUSSION

Tagging

Over 1,000 Beverly caribou (Table 1) and 202 Bathurst caribou have been collared (Table 2) since 1970 when Parker (1972a) compiled the tagging information for those two populations. Over 100 Kaminuriak caribou have been marked (Table 3) since 1965 when the initial tagging data were published by Miller and Robertson (1967).

The proportion of adult males tagged in the Beverly herd increased in the 1970's and the proportion of adult females decreased (Table 1). Almost all Bathurst caribou that were collared in 1979 were adult females (Table 2) because it was expected that collars could either fall off or injure males when their necks swelled during the rut. No Kaminuriak caribou calves were tagged after 1965 (Table 3).

Tag Recoveries

Since 1970, 88 tags that were attached to caribou at Box Crossing have been returned and one tag was recovered from a caribou tagged at Mary Frances Lake (Beverly herd; Table 4). Four of the tags applied to Bathurst caribou have been returned since 1968 and 12 caribou collared in 1979 were either shot or resighted (Table 5). Since 1965, 75 tags from caribou marked on the Kaminuriak herd's range have been recovered, the last one was shot in 1973 (Table 6). These recent tag returns represent 17%, 47% and 47% of all the tags so far recovered from the Beverly, Bathurst and Kaminuriak herds respectively and 25% of all returns.

Table 1. Age and sex of Beverly caribou tagged at Box Crossing and Mary Frances Lake.

Year	Adult males no. (%)[1]	Adult females no. (%)	Adult sex unknown no. (%)	Yearlings no. (%)	Calves no. (%)	Sex and age unknown no.	Total no.
1960-1967	1497(31)	1853(39)	1	1194(25)	241(5)	1665	6451
1972	18	41	0	52	2	0	113
1973	469	173	0	222	15	0	879
1977	-	-	-	-	-	≤ 20	20
1972-1973	487(49)	214(22)	0	274(28)	17(2)	20	1012
1960-1973	1984(34)	2067(36)	1	1468(25)	258(4)	1685	7463

1 percentages exclude unknowns.

Table 2. Age and sex of Bathurst caribou tagged at Contwoyto Lake.

Year	Adult males no. (%)[1]	Adult females no. (%)	Adult sex unknown no. (%)	Yearlings no. (%)	Calves no. (%)	Sex and age unknown no.	Total no.
1960-1969	62(14)	177(40)	4	89(20)	116(26)	288	476
1979	6(3)	194(96)	0	-	2(1)	-	202
1960-1979	68(11)	371(57)	4	89(14)	118(18)	28	678

1 percentages exlude unknowns.

Table 3. Age and sex of Kaminuriak caribou tagged in Manitoba.

Year	Adult males no. (%)[1]	Adult females no. (%)	Adult sex unknown no. (%)	Yearlings no. (%)	Calves no. (%)	Sex and age unknown no.	Total no.
1959-1965	931(41)	856(37)	6	169(7)	341(15)	136	2439
1966	23	2	0	0	0	0	25
1967	13	0	0	0	0	0	13
1970	12	53	0	10	0	0	75
1966-1970	48(42)	55(49)	0	10(9)	0(0)	0	113
1959-1970	979(41)	911(38)	6	179(7)	341(14)	136	2552

1 percentages exclude unknowns.

Table 4. Number of tagged Beverly caribou recovered each year from 1960 to 1981.

Tagging site	Year tagged	Number tagged	1960	61	62	63	64	65	66	67	68	69	Year ?	60-69 sub-total	70	71	72	73	74	75	76	77	78	79	80	81	Year ?	70-81 sub-total	Total	Percentage of tags recovered
Box Crossing	1960	50			1		1							2															2	4.0
	1962	618			3	11	7	6	5	2	4	1	1	40															40	6.5
	1963	1641				42	38	26	27	15	11	3	8	170	1	4	1	2										8	178	10.8
	1964	1692					28	26	23	11	13	8	4	113	3	1	5	4										13	126	7.4
	1965	1550						17	22	14	27	5	3	88	4	4	7	3	1									19	107	6.9
	1967	830								11	10	6		27	3	3	6	5		1		1	1		1			21	48	5.8
	1972	113																4			1							5	5	4.4
	1973	879																6	5		1	1	4	3				20	20	2.3
	1977	20																											0	0.0
	?												2	2													2	2	4	
Total		7393			4	53	74	75	77	53	65	23	18	442	11	12	19	24	6	1	2	2	5	3	1	0	2	88	530	7.2
Mary Frances Lake	1960	70	1	1	1	1	1	2		1				8				1										1	9	12.9
Beverly herd	Total	7463	1	1	5	54	75	77	77	54	65	23	18	450	11	12	19	25	6	1	2	2	5	3	1	0	2	89	539	7.2

Table 5. Number of tagged Bathurst caribou recovered each year from 1960 to 1981.

Year tagged	Number tagged	1960	1965	1966	1967	1968	60-69 sub-total	1970	1972	1974	1979	1980	1981	70-81 sub-total	Total	Percentages of tags recovered
1960	96	1	1		1		3							0	3	3.1
1964	21						0							0	0	0.0
1965	289		2	2	4	7	15	1	1					2	17	5.9
1969	70							1		1				2	2	2.9
1979	202										2	9	1	12	12*	5.9
Total	678	1	3	2	5	7	18	2	1	1	2	9	1	16	34	5.0

* Includes 4 animals resighted but not shot.

Table 6. Number of tagged Kaminuriak caribou recovered each year from 1960 to 1981.

Tagging site	Year tagged	Number tagged	1960	61	62	63	64	65	Year ?	60-65 sub-total	66	67	68	69	70	71	72	73	74-81	Year ?	66-81 sub-total	Total	Percentages of tags recovered
Duck Lake, Manitoba	1959	112	1		2	2				5												5	4.5
	1960	225	2	5	5			1	1	14		1									1	15	6.7
	1961	530			15	4	4	2	5	30	1	3			1						5	35	6.6
	1962	481			1	10	9	5	4	29	1	1									2	31	6.4
	1964	543					2	6		8	4	3			1						8	16	2.9
	1965	527									8	9	5	2	4	1		1			30	30	5.7
	1966	25										1									1	1	4.0
	1967	13										1	3	2	1		1				8	8	61.5
	1968	?											6		3			1		1	11	11	—
	1970	75													1	1	5	2			9	9	12.0
Total		2531	3	5	23	16	15	14	10	86	14	19	14	4	11	2	6	4	0	1	75	161	6.4

Of the 7,463 tags applied to Beverly caribou, 7.2% have been returned (Table 4). The return rates for the Bathurst and Kaminuriak herds were 5.0% (Table 5) and 6.4% (Table 6) respectively.

Combining all the tagging data except the Contwoyto Lake collars, the average interval between tagging and recovery was 2.6 years (31 months) with a maximum interval of 13 years. By the end of the fourth year (48 months) after tagging, 80% of all tags eventually recovered had been returned (Fig. 2).

Natural Mortality, Hunter Kill and Population Estimates

I attempted to estimate the average natural mortality rate of the marked population Caughley 1977: 166, model 6), but the data were inadequate. Because calves were identified at the time of tagging and because their mortality rate was undoubtedly higher than that of older caribou I omitted them from the analysis. I also subtracted all tag recoveries occurring within 1 month after tagging so that there would be a greater chance of satisfying the assumption of random mixing of the tagged and untagged populations. The mean mortality rate for the Kaminuriak caribou was negative; a biological impossibility. The mean mortatlity rate for the Beverly herd in the 1960's was 17% per year, for the 1970's it was 70% per year and when all Beverly data were combined it was 21% per year. I could not estimate the standard error of those measures but the wide ranges among results indicated the estimates were not precise, probably because of the small sample sizes.

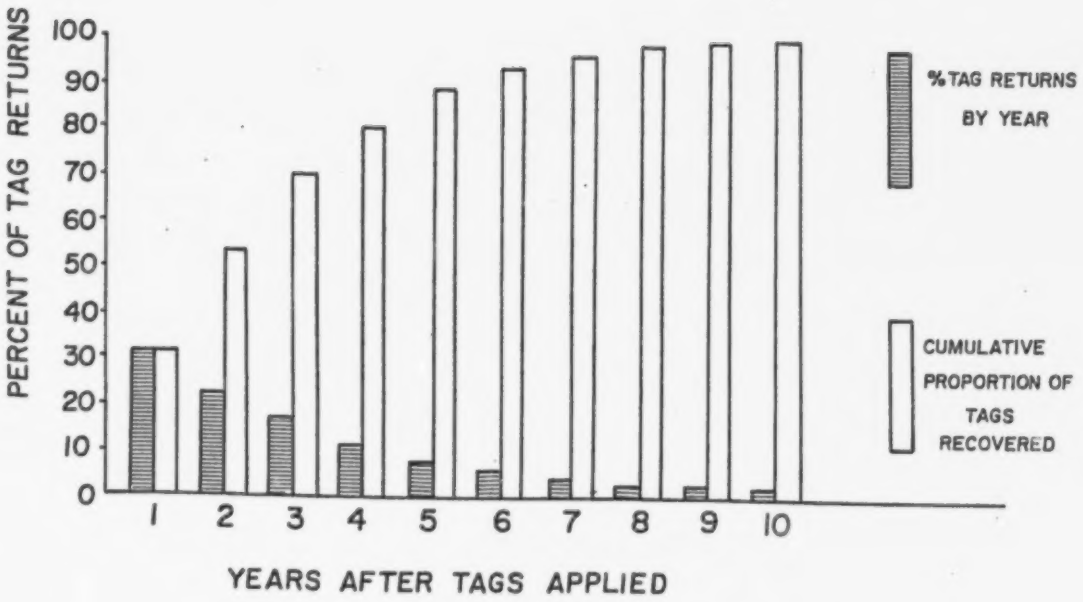

Figure 2. Proportion of all caribou ear-tags returned in each year (July to July) after tagging.

Tag returns underestimated the number of caribou shot by hunters. Based on the number of tags returned from each tagged cohort in the first year after tagging, it appeared that hunters shot an average of 2% of the caribou in all herds each year. However, the percent of the herd shot by hunters can be estimated only if 1) tagged caribou are representative of the entire herd, 2) there is no mortality of tagged caribou within 12 months of tagging, and 3) hunters report all tagged caribou shot. The latter two assumptions are definitely false and both will result in an underestimate of the hunter kill. Even voluntary annual reporting by hunters of all caribou shot indicated a larger kill of Kaminuriak caribou (about 5%, Parker 1972b) and voluntary reporting probably underestimates the true kill.

I did not attempt to estimate population sizes from tag recovery data because of the small sample sizes (see Parker 1972a) and the lack of estimates of the total number of caribou shot by hunters.

Distribution of Tagged Caribou

Tagged caribou in both the Beverly and Kaminuriak herds were shot north of the treeline throughout the year but most were killed from June through September and south of treeline caribou were shot primarily during January, February and March (Fig. 3).

More caribou are shot in winter (7 months long) than in summer (5 months long) in all areas (Table 7, 8, 9) probably because the winter season is longer, overland travel is easier and there are more communities and therefore more hunters on the winter ranges

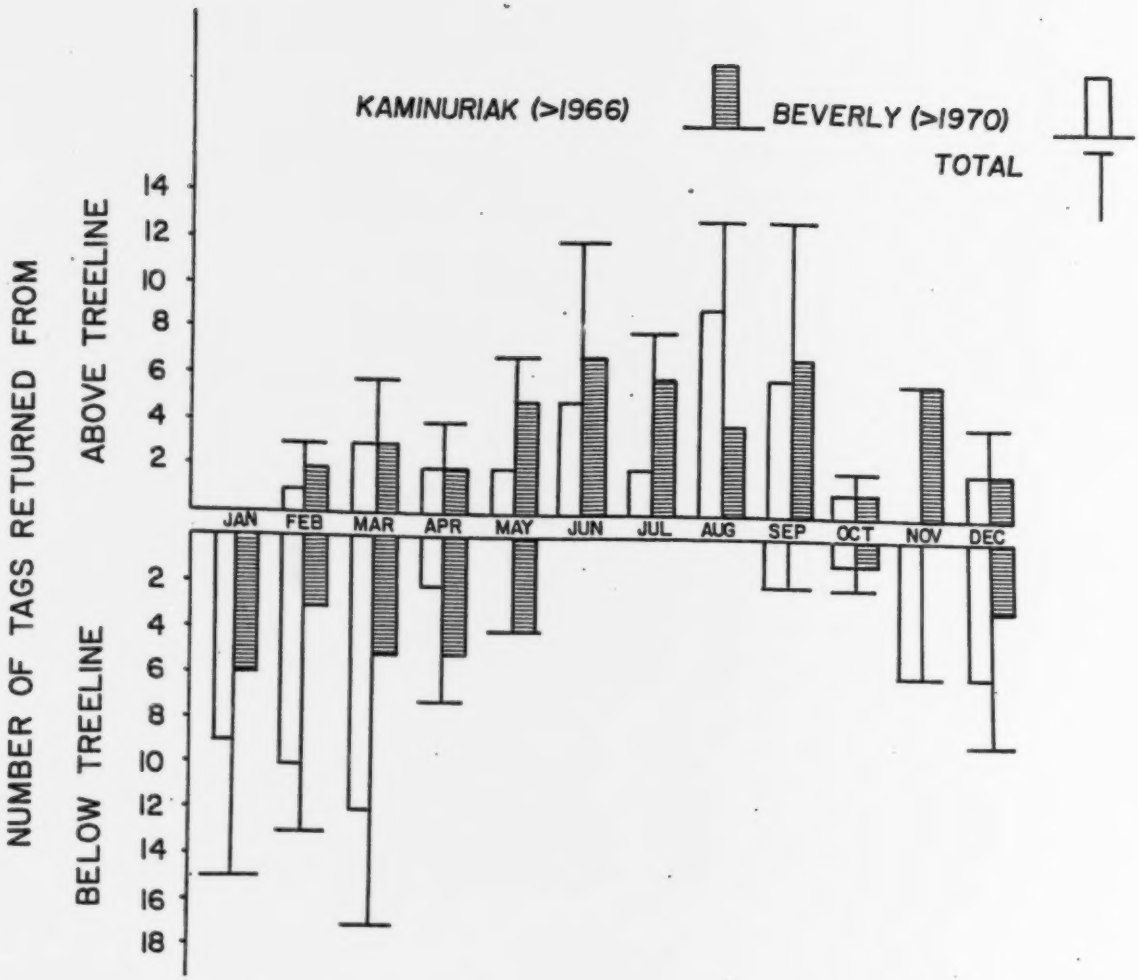

Figure 3. The number of Beverly and Kaminuriak caribou ear-tags returned my month above and below treeline.

Table 7. Age, sex and season shot for the 539 tagged Beverly caribou returned by hunters.

Season[1]	Adult males no. (%)[2]	Adult females no. (%)	Yearlings no. (%)	Calves no. (%)	Age and sex unknown no.	Total no.
Winter	184(56)	126(38)	17(5)	2(1)	15	344
Summer	74(43)	79(46)	17(10)	2(1)	5	177
Unknown	5	3	6	0	4	18
Total	263(51)	208(40)	40(8)	4(1)	24	539
% shot in winter[2]	71	61	50	50	75	66

1 Winter = October-April
Summer = May-September

2 Percentages exclude unknowns.

Table 8. Age, sex and season shot for the 30 marked Bathurst caribou resighted or returned by hunters.

Season[1]	Adult males no. (%)[2]	Adult females no. (%)	Age and sex unknown no.	Total no.
Winter	7(39)	11(61)	1	19
Summer	0(0)	2(100)	4	6
Unknown	0	0	5	5
Total	7(35)	13(65)	10	30
% shot in winter[2]	100	85	25	76

1 Winter = October-April
Summer = May-Spetember

2 Percentages exclude unknowns

Table 9. Age, sex and season shot for the 161 tagged Kaminuriak caribou returned by hunters.

Season[1]	Adult males no. (%)[2]	Adult females no. (%)	Yearlings no. (%)	Calves no. (%)	Age and sex unknown no.	Total no.
Winter	43(44)	43(44)	6(6)	6(6)	3	101
Summer	27(59)	18(39)	0(0)	1(2)	7	53
Unknown	3	1	0	0	3	7
Total	73(49)	62(42)	6(4)	7(5)	13	161
% shot in winter[2]	61	70	100	86	30	66

1 Winter = October-April
Summer = May-September

2 Percentages exclude unknowns.

(Fig. 1). The trend was the same throughout the entire tag return period (Appendices F, G, and H).

There were significantly more males shot in winter in the Beverly and Bathurst herds than would be expected based on the number tagged (Table 10). The high proportion of tagged males shot (relative to the proportion of males in the tagged sample) would result if hunters selectively shot males or if males were more available to hunters. Hunters generally prefer to eat females in winter so the bias toward males probably reflects increased availability. Males tend to go further south in winter than females which generally brings the males closer to the hunting communities (Fig. 1). Hunters did not select caribou of either sex on the Kaminuriak range in winter nor anywhere in summer (Table 10). These data cannot be used to estimate the sex ratio of untagged caribou shot by hunter because the sex ratio of the herds was not known.

The locations of tag returns indicated that the ranges of the Beverly, Bathurst, and Kaminuriak caribou herds are distinct and stable over time. There was virtually no change in the distribution of the Kaminuriak or Beverly tag returns throughout the tag recovery period. Most of the Kaminuriak tags both before and after 1966 were recovered near the communities of Brochet, Lac Brochet and Eskimo Point (Fig. 1 and Miller and Robertson 1967). Over 90% of the Kaminuriak tags were returned between 1962 and 1972. The reduction in the herd's range that occurred in the late 1970's (Simmons et al. 1979) was therefore not evident from those returns. Most of the Beverly tags from both thhe 1960's and the

Table 10. Number of adult caribou of both sexes tagged and recovered in winter and summer in all herds.

Herd	Sample	Males no. (%)	Females no. (%)	X^2
Beverly	Tagged	1984(49)	2067(51)	
	Winter returns	184(59)	126(41)	12.41**
	Summer returns	74(48)	79(52)	0.02NS
	All returns	258(56)	205(44)	
Bathurst	Tagged	66(14)	345(84)	
	Winter returns	7(39)	11(61)	6.37*
	Summer returns	0(0)	2(100)	
	All returns	7(35)	13(65)	
Kaminuriak	Tagged	979(52)	911(48)	
	Winter returns	43(50)	43(50)	0.11 NS
	Summer returns	27(60)	18(40)	1.18 NS
	All returns	70(53)	61(47)	

* $p<0.05$

** $p<.0.01$

NS = not significant

1970's came from west of Baker Lake, and north of Fond-du-Lac, Stony Rapids, Black Lake, Wollaston Lake, and Brochet (Fig. 1, Parker 1972a). Too few Bathurst tags were returned to clearly demonstrate range stability but the herd's range did appear to be distinct.

The only substantial area of overlap between herds was in northeastern Saskatchewan and northwestern Manitoba where 45 tags from both the Beverly and Kaminuriak herds were recovered (Figs. 1 and 4). Tags were returned from the overlap area throughout the tag recovery period.

Tag returns indicate the primary range used by each herd but in some areas where the density of tags gradually declined, the boundaries were difficult to distinguish. I drew boundaries around each herd based on tag returns and visual observations (Parker 1972b, Thomas 1969, Banfield 1954, Decker pers. comm., Fig. 4). All Bathurst tag recoveries fall within the boundary drawn for the herd but five Kaminuriak tags (3% of all Kaminuriak recoveries) and 14 Beverly tags (3% of all Beverly recoveries) were returned from beyond those boundaries (Fig. 4). I consider those 19 tag returns to be atypical.

Tagging has shown that the herds as defined by Thomas (1969) were discrete but that the wintering groups identified by Banfield (1954) were not. However, the 19 "atypical" recoveries (Table 11) suggest that although the Beverly, Bathurst and Kaminuriak herds are generally distinct, there is either 1) some dispersal to adjacent herds, 2) occasional and temporary movements of a few individuals beyond the areas used by the majority of the herd, or

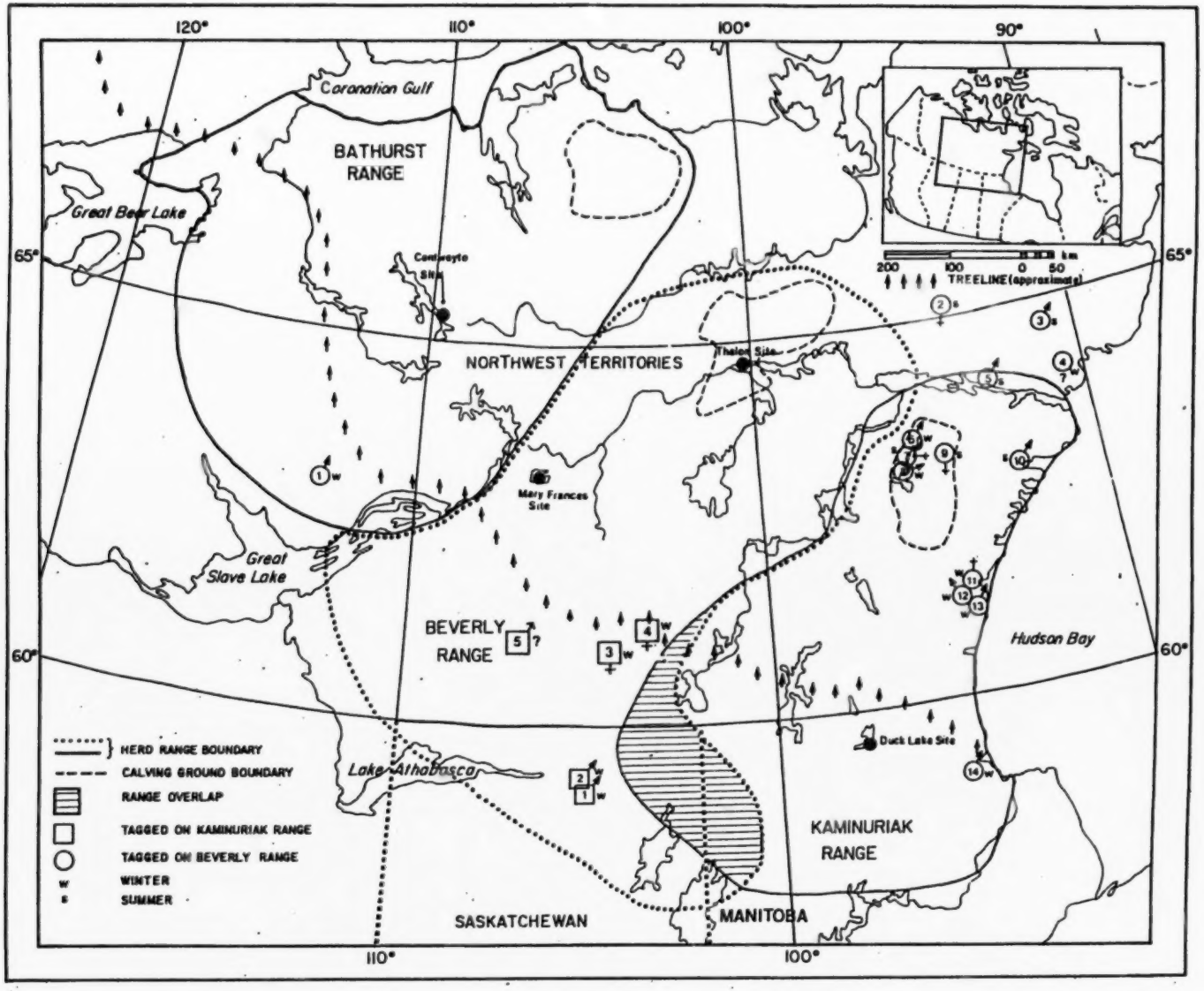

Figure 4. Distribution of the Bathurst, Beverly and Kaminuriak caribou herds between 1959 and 1981 based on tag return locations and direct observations, and the location of atypical tag recoveries.

Table 11. Sex, age when tagged, year tagged, and date shot for each caribou recovered from outside of the range where it was tagged.

Range where tagged	Animal number[1]	Tag number	Sex[2]	Age when tagged[2]	Year tagged	Date shot month/year
Kaminuriak	1	6	M	A	1960	1/62
	2	26	M	A	1961	1/62
	3	22	F	Y	1961	2/62
	4	78	F	A	1962	4/64
	5	123	M	A	1967	?/70
Beverly	1	427	M	A	1960	3/62
	2	1134	F	A	1962	8/63
	3	848	M	A	1962	7/65
	4	7759	?	?	1964	3/70
	5	6325	M	Y	1963	8/64
	6	8932	M	?	1965	12/66
	7	8672	F	?	1965	7/67
	8	6017	M	Y	1963	4/67
	9	7815	F	A	1964	7/67
	10	7802	M	A	1964	8/72
	11	96	F	A	1972	12/73
	12	20110 & 81	F	A	1967	3/80
	13	7612	F	A	1964	10/66
	14	6253	M	A	1963	1/65

1 refers to locations plotted on Figure 4.

2 A=adult, Y=yearling, M=male, F=female

3) both. Because these herds are defined on the basis of the calving ground with which each is associated, emigration can be demonstrated only when an animal tagged on its calving ground is found on a different calving ground during calving in another year. Two caribou from the Beverly herd (#7 and #9 on Fig. 4) satisfied the condition.

Inference about the status of those atypical individuals can be obtained by examining their sex, age, season shot and distance from normal range. In both herds the animals shot in atypical locations showed the same seasonal selection by sex as "typical" recoveries ($p>0.05$, Table 12 and Appendix I).

Atypical and typical recoveries from both herds showed the same degree of bias towards males ($p>0.05$, Appendix I). Four of the five atypical Kaminuriak recoveries (#1, 2, 3, and 4 on Fig. 4) were shot in the winter relatively close (within 100 km) to normally used winter range, suggesting that those animals were not emigrants. Three atypical Beverly recoveries #2, 3 and 5 on Fig. 4) could have been part of wandering post-calving groups that would later have returned. The other atypical Beverly returns appeared to be emigrants based on the time and location where they were shot. There appeared to be at least 11 Beverly recoveries which represented dispersers but probably only one of the atypical Kaminuriak returns was an emigrant. Using all 19 atypical recoveries, I estimated the mean dispersal rate from the Beverly herd at 1.8%/year and from the Kaminuriak herd at 2.4%/year. If only 11 of the Beverly and 1 of the Kaminuriak recoveries qualify as emigrants, the rates are reduced to 1.2% and 0.2%/year respectively (Appendix J).

Table 12. Sex, age and season shot of tagged caribou shot outside normal range as defined in Figure 4.

Herd	Adult males	Adult females	Unknown	Total
Kaminuriak (w+s+?)[1]	(2+0+1) 3	(2+0+0) 2[2]	0	(4+0+1) 5
Beverly (w+s)	(4+3) 7	(3+3) 6	(1+0) 1	(8+6) 14
Total	(6+3+1) 10	(5+3+0) 8	(1+0) 1	(12+6+1) 19

1 w=winter, s=summer, ?=season unknown.

2 one tagged and shot as a yearling.

Parker (1972a) considered 29 tags up to 1970 (20 from the Beverly herd and 8 from the Kaminuriak herd) as atypical. I have expanded the herd boundaries slightly to include some of those tags he considered out side the normal range of of their respective herds. His calculation of dispersal rate was incorrect (see Appendix J).

The dates of tagging and recovery of the 19 atypical caribou returns that I recognized do not suggest any single exodus involving large number of animals.

ACKNOWLEDGEMENTS

This paper could not have been written without the contributions made by the countless people who tagged caribou over the years and the many hunters and game officers who were responsible for the return of tags. I also thank Cam Elliott, Wendy Thompson and Mark Williams for their assistance in drafting and data analysis and Jackie Bell, Ellen Irvine and Seung Park for typing this paper and its many drafts.

PERSONAL COMMUNICATIONS

R. Decker, Arctic Land Use Research Technician, N.W.T. Wildlife Service, Yellowknife, N.W.T.

Doug Stewart, Regional Superintendent, Department of Renewable Resources, Inuvik, N.W.T.

LITERATURE CITED

Banfield, A.W.F. 1954. Preliminary investigations of the barren-ground caribou. Can. Wildl. Serv. Wildl. Manage. Bull. Ser. 1, No. 10A and 10B. 79 pp.

Calef, G.W. and D.C. Heard. 1980. The status of three tundra wintering caribou herds in northeastern mainland Northwest Territories. Pages 582-594 in: E. Gaare and S. Skenneberg, (eds.), Proc. 2nd Int. Reindeer/Caribou Symp., Røros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim. 799 pp.

Caughley, G. 1977. Analysis of Vertebrate Populations. John Wiley and Sons, London. 234 pp.

Engen, E. 1966. Barren-ground caribou tagging project in Manitoba. unpubl. rep. 17 pp.

Hawkins, R. 1973. Tagging report, 1973. Beverly Lake herd barren-ground caribou. N.W.T. Fish and Wildl. Serv. unpubl. rep. 68 pp.

Kelsall, J. 1966. The barren-ground tagging program in the NWT. Can. Wildl. Serv. unpubl. rep. 17 pp.

Miller, D.R., and J.D. Robertson. 1967. Results of tagging caribou at Little Duck Lake, Manitoba. J. Wildl. Manage. 31:150-159.

Miller, F.L., F.W. Anderka, C. Vithayasai, and R.L. McClure. 1975. Distribution, movements and socialization of barren-ground caribou radio-tracked on their calving areas. Pages 423-435 in: J.R. Luick, P.C. Lent, D.R. Klein and R.G. White, (eds.), Proc. First Int. Reindeer/Caribou Symp., Univ. of Alaska, Fairbanks. 551 pp.

Mitchell, B. 1980. Bathurst caribou collaring project Contwoyto Lake, July 26-August 3, 1979. N.W.T. Wildl. Serv. File Rep. No. 9. 23 pp.

Moshenko, D.L. 1972. Caribou tagging project Beverly Lake herd, July 1972. N.W.T. Fish and Wildl. Serv. unpubl. rep. 9 pp.

Parker, G.R. 1967. The 1967 barren-ground caribou tagging project, Aberdeen Lake, N.W.T., June-July 1967. Can. Wildl. Serv. unpubl. rep. 46 pp.

Parker, G.R. 1972a. Distribution of barren-ground caribou harvest in north-central Canada, Can. Wildl. Serv. Occ. Pap. No. 15. 20 pp.

Parker, G.R. 1972b. Biology of the Kaminuriak population of barren-ground caribou. Part 1. Total number, s mortality, recruitment, and seasonal distribution. Can. Wildl. Serv. Rep. Ser. No. 20. 93 pp.

Ruttan, R.A. 1962. 1962 caribou tagging operations, Thelon River. Can. Wildl. Serv. unpubl. rep. 10 pp.

Ruttan, R.A. 1965. Progress report on the N.W.T. barren-ground caribou tagging program. Can. Wildl. Serv. unpubl. rep. 60 pp.

Ruttan, R.A. 1966. Summary of 1965 Contwoyto Lake tagging operation. Letter to J. Kelsall. 2 pp.

Ruttan, R.A. 1969. Tagging-Bathurst Inlet barren-ground caribou, August, 1969. unpubl. rep. 5 pp.

Simmons, N.M., D.C. Heard, G.W. Calef. 1979. The Kaminuriak caribou herd: Interjurisdictional management problems. Trans. North Amer. Nat. Res. Conf. 44:102-106.

Thomas, D. 1960a. A report on the tagging operations. Beverly-Aberdeen Lakes. July 8 to July 19, 1960. Can. Wildl. Serv. Rep. 30 pp.

Thomas, D. 1960b. Tag Record. Can. Wildl. Serv. unpubl. rep. Job No. M2-2, Job 1. 3 pp.

Thomas, D. 1960c. Caribou tagging at Contwoyto Lake - August 1960. Can. Wildl. Serv. unpubl. rep. 12 pp.

Thomas, D. 1969. Population estimates and distribution of barren-ground caribou in Mackenzie District, NWT, Saskatchewan, and Alberta - March to May 1967. Can. Wildl. Serv. Rep. Ser. No. 9. 44 pp.

Appendix A. Number and description of ear tags applied between 1960 and 1977 to Beverly caribou at Box Crossing on the Thelon River and at Mary Frances Lake.

Area	Year tags applied	Number of caribou tagged	Tag description	Tag numbering series	Reference[1]
Box Crossing	1960	50	Ketchum VISA square anodysed gold aluminum ear tags. Red or red and grey Herculite (#80) streamers (1.5"x6") attached.	36 to 92	Thomas (1960a)
	1962	618	Ketchum VISA square anodysed blue (#601-1000) and yellow enamel (#1001 to 1500) ear tags. Red or red and grey Herculite (#80) streamers (1.5"x6") attached.	601 to 1000 1001 to 1500	Ruttan (1962) Ruttan (1965)
	1963	1641	Ketchum VISA round red enamel ear tags. Translucent red vinyl-coated nylon streamers attached.	5001 to 6655 6701 to 6726	Ruttan (1965)
	1964	1692	Ketchum VISA round red enamel ear tags. Translucent yellow vinyl-coated nylon streamers attached.	6657 to 6700 6727 to 7345 7401 to 7500 7518 to 7723 7800 to 8559	Ruttan (1965)
	1965	1550	Ketchum VISA red ear tags and green nylon swivel tags. Vinyl-coated streamers (1.5" to 8" or 0.5" x3") attached.	8589 to 9973 (approximate)	Kelsall (1966) and Parker (1972a)

Appendix A. (continued)

Area	Year tags applied	Number of caribou tagged	Tag description	Tag numbering series	Reference[1]
Box Crossing	1967	830	Hasco aluminum cattle ear tags (size 49) green Herculite (#80) streamers attached. 520 caribou were also marked with a numbered (series unknown) yellow collar (30" long for males, 22" long for females; all 4" wide).	20001 to 20845	Parker (1967)
	1972	113	Hasco aluminum cattle ear tags (size 49) imprinted with "N.W.T. G.M.S./Yellowknife".	1 to 37 51 to 128	Moshenko (1972)
	1973	879	Hasco aluminum cattle ear tags (size 49) imprinted with "N.W.T. G.M.S./Yellowknife".	38 to 50 129 to 1000	Hawkins (1973)
	1977	about 20	Yellow plastic Starbar ear tag.	?	Doug Stewart (pers. comm.)
Mary Frances Lake	1960	70	Ketchum VISA square anodyzed gold aluminum ear tags. Red and grey Herculite (#80) streamers (1.5"x6") attached.	4 to 12, 14, 19, 20, 24, 26, 30, 32 to 35, 93 to 95	Thomas (1960b) and Ruttan (1965)
			Ketchum VISA square anodyzed blue aluminum ear tags. Red and grey Herculite (#80) streamers (1.5"x6") attached.	401 to 416 427 to 440	

1 Not all tagging details were available in the references cited.

Appendix B. Number and description of ear tags applied between 1960 and 1979 to Bathurst caribou at Contwoyto Lake.

Year tags applied	Number of caribou tagged	Tag description	Tag numbering series	Reference
1960	96	Ketchum VISA anodyzed blue ear tags. Red and grey Herculite (#80) streamers (1.5"x6") attached.	419, 421, 464 to 563	Thomas (1960c)
1964	21	Ketchum VISA round gold anodyzed tags. Translucent red vinyl-coated nylon streamers (1.5"x6") attached.	A010 to A028 letter a printed above the digits	Ruttan (1965)
1965	289	Green enamel metal disc ear tags.	A1 to A291 letter printed about the digits.	Ruttan (1966)
1969	70	Ketchum VISA anodyzed gold aluminum ear tags with flourescent red vinyl streamers (2" long) on most tags.	030A to 101A	Ruttan (1969)
1979	202	Yellow collar; rubberized fiberglass 13 cm wide, stapled to fit.	various-character letter and/or number combinations (Appendix C)	Mitchell (1980)

Appendix C. Numbering series for caribou tagged between July 28 and August 1, 1979 at the Contwoyto Lake site[1].

Date	No. of caribou	Number on tag
July 28	20	J1, J2, J3, J4, J5, J6, J7, J8, J9, KA, KD, KM[2], KN[2], N7, N8, N9, NH, PA, PG, PH.
July 29	105	KT, KK, KJ, KH, KG, KE, KC, AC, AD, AE, AG, AH, AJ, AK, AL, AM, AN, AP, AT, AU, AX, AY, AZ, A1, A2, A3, A4, A5, A6, A7, A8, A9, CA, CC, CD, CE, CG, CH, CJ, CK, CL, CM, CN, CP, CT, CU, CX, CY, CZ, C1, C2, C3, C4, C5, C6, C7, C8, C9, DA, DC, PC, PD, PE, N6, N5, N4, N3, N2, N1, NZ, NY, NX, NU, NT, NP, NN, NM, NL, NJ, NK, NG, NE, ND, NC, NA, M1, M2, M3, M4, M5, M6, M7, M8, M9, MZ, MY, MX, MU, MT, MP, MN, MM, LK, LL, LM,
July 30	59	DD, DE, DG, DH, DJ, DK, DL, DM. DN, DM, DN, DU, DP, DT, DX, DY, DZ, D1, D2, D3, D4, D5, D6, D7, D8, D9, EA, EC, EG, EH, EJ, EK, EL, EM, EN, EP, LN, LP, LT, LU, LX, LY, LZ, L1, L2, L3, L4, L5, L6, L7, L8, L9, MA, MC, MD, ME, MG. MH, MJ, MK, ML,
July 31	12	E7, E8, E9, EE, EU, GA, GC, GD, GE, GJ, GM, GN,
August 1	6	HL[3], HM[3], GZ[3], G4[3], HA[3], HD[3].
Total	202	

1 from Mitchell (1980)
2 calves (n=2)
3 bulls (n=6)

Appendix D. Number and description of ear tags applied between 1959 and 1970 to Kaminuriak caribou.

Year tags applied	Number of caribou tagged	Tag description	Tag numbering series[1]	Reference
1959	112	Hasco metal ear tags with yellow Herculite streamers (8" long).	101 to 229	Miller and Robertson (1967)
1960	225	Hasco metal ear tags with yellow Herculite streamers (8" long).	1 to 248	Miller and Robertson (1967)
1961	530	Hasco metal ear tags with yellow Herculite streamers (6" long).	301 to 890, 12004	Miller and Robertson (1967)
1962	481	Hasco metal ear tags with yellow Herculite streamers (6" long).	250 to 300, 654 to 700, 901 to 998, 1501 to 1742, 1101 to 1149	Miller and Robertson (1967)
1964	543	Hasco metal ear tags with yellow Herculite streamers (6" long).	1153 to 1500, 1744 to 1948 2101 to 2104	Miller and Robertson (1967)
1965	527	Hasco metal ear tags with yellow Herculite streamers (6" long).	1949 to 2100, 2105 to 2428, 2501 to 2525.	Miller and Robertson (1967)
1966	25	Hasco metal ear tags. 9 caribou also given flourscent vinyl collars; and one with a collar and no tags (9 green and one pink all marked with one black letter).	2431 to 2440, 2507 to 2525	Engen (1966)
1967	13	Hasco metal ear tags and orange collars.	2438 to 2706 tags, 1 to 162 collars.	Miller and Robertson (1967)

Appendix D (continued)

Year tags applied	Number of caribou tagged	Tag description	Tag numbering series[1]	Reference
1968	?	Numbered silver metal ear tags at least some with pink streamer attached and other pink or green numbered collar.	?	Tag return description (N.W.T.W.S. files)
1970	75[2]	Metal ear tags with 64 also with green or pink numbered collars 27 of which included a radio transmitter.	20789 to 21086 tags 1-69 pink collars 1-9 green collars	Miller et al. (1975) and[3] Anonymous

1 see Appendix E for details
2 winter captures
3 Anonymous typescript titled "Appendix III".

Appendix E. Numbering series for Kaminuriak caribou tagged between 1959 and 1970.

Year	No. applied	Series	Comments
1959	112	101-229	Not applied: 103, 124, 135, 149, 154, 207, 208, 209, 210, 220-225, 228.
1960	225	1-248	Not applied: 3, 18, 44, 85-100, 126, 280, 208.
1961	530	301-890 12004	Not applied: 390, 403, 463, 549, 604, 611, 644, 652-700, 738, 740, 865, 866.
1962	481	250-300	Not applied: 266, 275, 280.
		654-700 901-998	Not applied: 902, 920.
		1501-1742	Not applied: 1631, 1690.
		1101-1149	
1964	543	1153-1500	Not applied: 1339, 1393, 1417, 1443, 1481, 1494, 1499.
		1744-1948	Not applied: 1749, 1751, 1757,
		2101-2104	1780, 1800.
1965	527	1949-2100 1205-2428 2501-2606	No data: 1967, 1986, 2005, 2024, 2043, 2080, 2099, 2158, 2177, 2213, 2233, 2252, 2271, 2290, 2309, 2328, 2347, 2385. Not applied: 1955, 1956, 1958, 1981, 1990, 2012, 2018, 2037, 2071, 2088, 2106, 2109, 2119, 2143, 2165-2174, 2178-2180, 2183, 2193, 2197, 2200, 2203, 2206, 2229, 2230, 2241, 2341, 2361, 2387, 2394, 2399, 2570, 2578, 2579, 2580, 2600.
1966	25	2431-2440 2507-2525	Not applied: 2438, 2508, 2513
1967	13	2438, 2441, 2443, 2801-2805, 2701-2706	Not applied: 2703
1968	?	21900 and up	Tagging data apparently lost.

Appendix E. continued

Year	No. applied	Series	Comments
1970	75	20789-20800 20846-20850 20924 20929-20940 20944-20988 20990, 20997, 21000, 21086.	Not applied: 20967, 20976, 20981, 20986.

Appendix F. Age, sex and season shot for tagged Beverly caribou returned by hunters before and after 1970.

Years	Season[1]	Adult males no. (%)[2]	Adult females no. (%)	Yearlings no. (%)	Calves no. (%)	Unknown no.	Total no. (%)
1960-1969	winter	151(56)	100(37)	16(6)	2(1)	14	283(100)
	summer	66(44)	67(45)	15(10)	2(1)	4	154(100)
	unknown	5	3	6	0	0	14
	Total	222(51)	170(39)	37(9)	4(1)	18	451(100)
	% shot in winter	70	60	52	50	78	65
1970-1981	winter	33(55)	26(43)	1(2)	0	1	61(100)
	summer	8(36)	12(55)	2(9)	0	1	23(100)
	unknown	0	0	0	0	4	4
	Total	41(50)	38(46)	3(4)	0	6	88(100)
	% shot in winter	80	68	33	0	50	73

1 winter = October-April
summer = May-September

2 percentages exclude unknowns.

Appendix G. Age, sex and season shot for tagged Bathurst caribou returned by hunters before and after 1970.

Year	Season[1]	Adult male no. (%)[2]	Adult female no. (%)	Unknown no.	Total no. (%)
1960-1969	winter	7(70)	3(30)	1	11(100)
	summer	0	2(100)	1	3(100)
	unknown	0	0	4	4
	Total	7(58)	5(42)	6	18(100)
	% shot in winter	100	60	50	79
1970-1981	winter	0	8(100)	0	8(100)
	summer	0	0	3	3
	Total	0	8	0	11(100)
	% shot in winter	0	100	0	73

1 winter = October-April
summer = May-September

2 percentages exclude unknowns.

Appendix H. Age, sex and season shot for tagged Kaminuuriak caribou returned by hunters before and after 1966.

Years	Season[1]	Adult males no. (%)[2]	Adult females no. (%)	Yearlings no. (%)	Calves No. (%)	Unknown no.	Total no. (%)
1960-1969	winter	28(50)	26(46)	1(2)	2(1)	2	58(100)
	summer	11(58)	8(42)	0	0	5	24(100)
	unknown	2	1	0	0	1	4
	Total	41(53)	35(45)	1(1)	1(1)	8	86(100)
	% shot in winter	72	76	100	100	29	71
1970-1981	winter	15(36)	17(40)	5(12)	5(12)	1	43(100)
	summer	16(59)	10(37)	0	1(4)	2	29(100)
	unknown	1	0	0	0	2	3
	Total	32(46)	27(39)	5(7)	6(9)	5	75(101)
	% shot in winter	48	63	100	83	33	60

1 winter = October-April
summer = May-September

2 percentages exclude unknowns.

Appendix I. Comparisons of sex ratio and season shot for caribou recovered from atypical locations with those caribou recovered from within the normal range of Beverly and Kaminuriak herds.

		Winter	Summer	Total
Beverly males recoveries	normal	180	71	251
	atypical	4	3	7
	Total	184	74	258
		$X^2 = 0.707$		
Beverly females recoveries	normal	123	76	199
	atypical	3	3	6
	Total	126	79	206
		$X^2 = 0.343$		
Kaminuriak male recoveries	normal	41	27	68
	atypical	2	0	2
	Total	43	27	70
		$X^2 = 1.293$		
Kaminuriak female recoveries	normal	41	18	59
	atypical	2	0	2
	Total	43	18	61
		$X^2 = 0.866$		
All Beverly recoveries	normal	337	171	508
	atypical	7	6	13
	Total	344	177	521
		$X^2 = 0.882$		

Appendix I (continued)

		Winter	Summer	Total
All Kaminuriak recoveries	normal	96	53	149
	atypical	5	0	5
	Total	101	53	154
		$X^2 = 2.712$		
All male recoveries	normal	221	98	319
	atypical	6	3	9
	Total	227	101	9
		$X^2 = 0.028$		
All female recoveries	normal	164	94	258
	atypical	5	3	8
	Total	169	97	266
		$X^2 = 0.004$		
All recoveries	normal	433	224	657
	atypical	12	6	18
	Total	445	230	675
		$X^2 = 0.005$		

Appendix I (continued)

		Male	Female	Total
Kaminuriak herd recoveries seasons combined	normal	70	60	130
	atypical	3	2	5
	Total	73	62	135
		$X^2 = 0.073$		
Beverly herd recoveries seasons combined	normal	256	200	456
	atypical	7	8	15
	Total	263	208	471
		$X^2 = 0.529$		
All recoveries seasons combined	normal	326	262	588
	atypical	10	8	18
	Total	336	270	606
		$X^2 = 0$		

$p>0.05$ for all chi-square values.

Appendix J. Methods and calculations of dispersal rates from tag recovery data.

Dispersal rate is the proportion of animals from one population that emigrate to another during some time interval. A cohort is a group of caribou tagged in a given year at the same place. For any given year the dispersal rate can be estimated by comparing the number of emigrants and the number of residents recovered from each tagged cohort during that year. Beginning year one with the first cohort the dispersal rate (D_1) is simply:

$$D_1 = E/N$$

where: E = the number of emigrants, and

N = the number of tagged caribou recoverer (emigrants & residents).

Two years after tagging the dispersal rate estimate is actually an independent estimate of the mean dispersal rate over the past two years. This estimate must be divided by two to give a mean annual dispersal rate (D). The general formula for any time since tagging is:

$$D_y = (E_y/y) /N_y$$

where: y = the number of years since the cohort was tagged,

E_y = number of emigrants recovered in year y,

N_y = number of tagged caribou recovered in year y from the cohort tagged y years ago, and

D_y = mean annual dispersal rate over past y years.

When these calculations are carried out for each cohort tagged, one ends up with many estimates of the annual dispersal rate covering various times over the tag recovery period. Because sample sizes are small, with many zero estimates, I thought that the best way to estimate the annual dispersal rate for the entire period was to calculate a mean, weighted by sample size but independent of the year in which the estimate was obtained. That is, I gave the estimate of the mean annual dispersal rate calculated on data from year 2 the same weight as that calculated on data from years 1, 3, 4 etc. Weighting was accomplished by adding the numerators and denominators before dividing. For example, if one has the following data covering two years:

Year	E	N
1	2	100
2	1	50

$$D_1 = 2/100 = .02$$

$$D_2 = 1/2/50 = .01$$

$$\text{then } D = (2+1/2)/(100+50)$$

$$= 2.5/150$$

$$= .017$$

where D = the weighted mean annual rate dispersal rate over those two years.

The following assumptions are necessary:

1) residents and dispersers had the same mortality rate and the same chance of being recovered (i.e., equal hunting pressure in all areas),

2) tagged animals are representative of untagged animals in the population (recoveries occurring within the first 6 months after tagging were eliminated to increase likelihood that this assumption would hold),

3) dispersal occurred at a continuous rate thoughout the tagging and tag recovery period, and

4) animals shot outside the "normal" herd range would not have returned if they had not been shot (i.e., the movement was not temporary).

The general equation for multiple cohorts and any number of recovery years is:

$$D = \frac{(E_{1,1}/1)+(E_{1,2}/2)+\ldots+(E_{1,my}/my)+(E_{2,1}/1)+\ldots+(E_{mc,my}/my)}{N_{1,1} + N_{1,2} +\ldots+ N_{1,my} + N_{2,1}\cdots + N_{mc,my}}$$

$$D = \frac{\sum_{c=1}^{mc}\sum_{y=1}^{my} E_{c,y}/y}{\sum_{c=1}^{mc}\sum_{y=1}^{my} N_{c,y}}$$

where $E_{c,y}$ = the number of dispersers, from cohort c, and recovered y years after being tagged,

$N_{c,y}$ = the number of all tagged caribou, from cohort c recovered y years later.

mc = maximum number of cohorts tagged.

and my = maximum number of years over which caribou from cohort c, were recovered.

Calculations

1. Kaminuriak herd

Of the 161 Kaminuriak tags returned 13 were eliminated because they were returned within the first 6 months after tagging and 11 were eliminated because they year of recovery was unknown (Table 9). Thus:

$$\sum_{c=1}^{mc}\sum_{y=1}^{my} N_{c,r} = (161-13-11) = 137$$

The five tag recoveries occured in four different years so $E_{c,y}$ equals zeros for all cases except

$c = 1960,\ y = 2,\ E_{1960,2} = 1,$

$c = 1961,\ y = 1,\ E_{1961,1} = 2,$

$c = 1962,\ y = 2,\ E_{1962,2} = 1,$

and $c = 1967,\ y = 3,\ E_{1967,3} = 1.$

Thus $D = (1/2+2/1+1/2+1/3) / 137$

$D = 3.333/137$

$= 0.024$

or $= 2.4\%/yr$

The mean annual dispersal rate from the Kaminuriak herd was 2.4%/yr.

2. Beverly herd

Of the 536 Beverly tags returned 108 were returned within 6 months and the return year was not recorded for 20. Thus:

$$\sum_{c=1}^{mc}\sum_{y=1}^{my} N_{c,y} = (539-108-20) = 411$$

$E_{c,y}$ equals zero for all cases except the following where $E_{c,y}$ equals one.

cohort (c)	years between tagging and recovery(y)
1960	2
1962	1
1962	3
1963	1
1963	2
1963	4
1964	2
1964	3
1964	6
1964	8
1965	1
1965	2
1967	13
1972	1

Thus $D = \frac{1/2+1+1/3+1+1/2+1/4+1/2+1/3+1/6+1/8+1+1/2+1/13+1}{411}$

$= 7.28/411$

$= 0.018$

or $= 1.8/\%$ yr

The mean annual dispersal rate from the Beverly herd was 1.8% yr.